UNITED STATES MARINE CORPS
Basic Officer Course
The Basic School
Marine Corps Combat Development Command
Quantico, Virginia 22134-5019

B1405

DIRECTION

Student Handout

1. **Direction**

   a. Definition. Position of one point in relation to another point.

   b. Elements

      (1) An understood base line

      (2) An angle measured from that base line

2. **Base (North) Lines**

   a. True north

      (1) At North Pole

      (2) Shown by lines of longitude

      (3) Not used by infantry platoon commanders

   b. Magnetic north

      (1) North to which compass points

      (2) Lines not shown on map

      (3) Used to navigate in the field

   c. Grid north

      (1) Parallel lines on the map

      (2) Do not converge at North Pole

      (3) Set up by map makers

3. **Declination**

   a. Definition. The angular difference between true north and grid north or magnetic north.

   b. Magnetic declination

      (1) Measures from true north to magnetic north

      (2) Can be east or west

      (3) Usually measured in degrees

c. Grid declination

(1) Measures from true north to grid north

(2) Can be east or west

(3) Usually measured in degrees

4. **Azimuth**

a. Definition. A horizontal angle measured clockwise from a base line. This can be from any of the three base lines described above.

b. Determining a grid azimuth

(1) Determine the start point and objective.

(2) Draw a line between these points. Ensure this line is at least two inches long to facilitate use of the protractor.

(3) Place protractor so that the words "index point" are readable.

(4) Center the tip of the index point at the center of mass of the object from which you are measuring.

(5) Align the alignment lines exactly parallel to the north/south grid line.

(6) Read the grid azimuth from the degree scale.

c. Determining a back azimuth

(1) Definition. The reverse (plus or minus 180°) of an azimuth, either magnetic or grid.

(2) To determine:

(a) If original azimuth is less than 180°, add 180°.

(b) If original azimuth is more than 180°, subtract 180°.

(c) Example:

14°	310°
+180°	-180°
194°	130°

5. **GM Angle (Grid to Magnetic Angle)**

a. Definition. Angular difference between grid north and magnetic north measured from grid north to magnetic north.

b. Direction can be either east or west.

c. Sample: (Solve for GM angle)

Answer: 5° E

d. Used to convert grid azimuths to magnetic and vice versa.

6. **Converting Azimuths**. There are two basic methods for converting azimuths. Both methods are effective, and user preference prevails. As a leader/teacher you must know both.

a. Magnetic Azimuth ± GM angle = Grid Azimuth

(1) If the GM angle is East you add.

(2) If the GM angle is West you subtract

MA ± GM = GA This method simply expresses the
E + verbiage next to the declination
W - diagram as an equation.

Example: magnetic declination = 5° W
grid declination = 2° E
grid azimuth = 217°
GM angle =
magnetic azimuth

Steps: 1. Write formula.

MA ± GM = GA
E +
W-

2. Fill in the blanks.

MA - 7° = 217°

3. Solve for MA.

MA - 7° + 7° = 217° + 7°

MA = 224°

b. LARS = Left Add Right Subtract This is probably the simplest method. Most Marines will use LARS.

(1) Determine which AZ is known. If the grid azimuth is known, start at the grid declination line on your declination diagram and count the number of degrees you must travel to get to the magnetic declination line. If the magnetic azimuth is known, start at the magnetic declination line and count the number of degrees you must travel to get to the grid declination line. The resulting number equals the number of degrees in your GM angle.

(2) If you traveled Left, Add the GM angle to the known azimuth to determine the unknown azimuth. If you traveled Right, Subtract the GM angle from the known azimuth to determine the unknown azimuth.

Example: magnetic declination = 4° E
grid declination = 1° W
grid azimuth = 108° GM angle =
magnetic azimuth =

Steps: 1. The GA is known. Start at the grid declination line and move to the magnetic declination line to determine the number of degrees in your GM angle.

2. Since you traveled to the Right, you will Subtract the GM angle from the GA to determine the MA:

108° - 5° = 103° = MA

7. **Conversion Problems**:

a.

magnetic declination	2° E
grid declination	5° E
magnetic azimuth	197°
grid azimuth	?

Answer 194°

b.

magnetic declination	2° W
grid declination	4° E
grid azimuth	48°
magnetic azimuth	?

Answer 54°

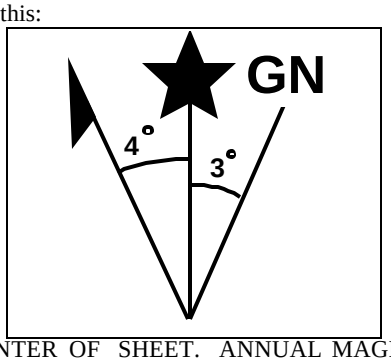
8. **Annual Magnetic Change**: The magnetic declination (relationship between magnetic north and true north and, by association, grid north) changes daily in minute and largely unpredictable increments. In time, these small changes will add up and change the relationship between grid north and magnetic north (the GM angle) to the point where it will affect navigation. Hence, the need to update the declination information.

a. Three methods of updating GM angle:

(1) Call Defense Mapping Agency (DMA) or United States Geological Survey (USGS) and request changes (go through unit intelligence officer, the S-2). This is the method of choice.

(2) Some older maps may have a "projected annual magnetic change" statement at the bottom of the declination diagram. If DMA or USGS cannot be contacted, utilize this "projected" data.

(a) This statement will look like this:



APPROXIMATE MEAN DECLINATION 1964 FOR THE CENTER OF SHEET. ANNUAL MAGNETIC CHANGE 9' EASTERLY.

(b) To solve for current GM angle (assume it is 1991):

1 Determine # of years:
1991
-1964
27

2 Multiply # years by annual change:

27yrs x 9'/yr = 243'

3 Determine # of degrees of change (if any):

243' □ 60'/degree = 4.05° E
= 4.0° E (round to nearest .5°)

4 Apply change to update GM angle:

Old GM>	Change	Current GM
7° W	- 4° E	= 3° W

(3) The third method is the "real world/map comparison method." It is, by far, the least preferred - it is only to be used in a worst case scenario. That would be when you do not have the time or means to contact DMA or USGS and you are using a very old map that does not have a "projected annual magnetic change" statement. In short, this is a survival method. This technique is detailed below:

(a) Identify two known, manmade points you can see in the real world that you can also find, without a shadow of a doubt, on the map. Use "solid" features such as water towers, radio towers, primary/secondary road intersections, etc.

(b) Taking great care, determine a grid azimuth between these two known points.

(c) Using the most accurate compass available (borrow an aiming circle from the 81mm plt or any artillery unit or, if this is not possible, borrow an M2 compass from the same source) shoot a magnetic azimuth between the points.

(d) The difference between these grid and magnetic azimuths is a very "rough" GM angle.

(e) Before you use this "approximate" GM angle, repeat the process utilizing other known points until you are confident of your findings.

APPENDIX A

REQUIREMENT 1

Map: Margarita Peak, California, 1:50,000, Sheet 2550 IV, Series V795, Edition 8-NIMA

SECTION 1

1. What is the GM angle in the following diagram?

ANS.

2. What is the grid azimuth in the following diagram

ANS.

3. Draw the diagram and solve the following:

a.

magnetic declination	3° E
grid declination	7° E
magnetic azimuth	209°
grid azimuth	?

ANS.

b.

grid declination	7° E
magnetic declination	5° W
magnetic azimuth	92°
grid back azimuth	?

ANS.

4. Starting at Hill 236 in GS 6593, moving on a magnetic azimuth of 216 degrees, how many streams are indicated on your map between your start point and Basilone Road?

ANS.

5. What is the magnetic azimuth from:

a. the windmill in GS 5981 to the improved surface road junction in GS 5685?

ANS.

b. horizontal control station 229 in GS 6085 to spot elecation 321 in GS 6287?

ANS.

NOTE: The solutions for Section 1 are on the Solution Sheet. Check these to determine the accuracy of your work. Make necessary corrections. Proceed to Section 2.

SECTION 2

1. What is the GM angle in the following diagram?

ANS.

2. What is the grid back azimuth in the following diagram?

ANS.

3. Draw the diagrams and solve the following:

a. GM angle 6° W
grid azimuth 149°
magnetic azimuth ?

ANS.

b. grid declination 4° W
magnetic declination 1° W
magnetic azimuth 200°
grid back azimuth ?

ANS.

4. Starting from the westmost intersection of Roblar road and Basilone road in GS 6690 and moving at a magnetic azimuth of 210 degrees for 600 meters, how many times will you cross the trail?

ANS.

5. From the windmill in GS 5599 you can see an enemy tank on a magnetic azimuth of 180°. On what grid azimuth would the enemy tank see you?

NOTE: The solutions for Section 2 are on the Solution Sheet. Check these to determine the accuracy of your work. Make necessary corrections. Proceed to Section 3.

Section 3

1. What is the GM angle in the following diagram?

ANS.

2. What is the grid back azimuth in the following diagram?

ANS.

3. Draw the diagrams and solve the following:

a. GM angle 5° E
grid azimuth 199°
magnetic back azimuth ?

ANS.

b. grid declination 5° W
magnetic declination 3° W
magnetic azimuth 163°
grid back azimuth ?

ANS.

4. From the windmill in GS 5883, and moving on a magnetic azimuth of 169 degrees, what is the first manmade object you encounter?

ANS.

5. From the tank in GS 6483 to BM 15.2 in GS 6581:

a. What is the magnetic azimuth?

ANS.

b. What is the magnetic back azimuth?

ANS.

6. Given the following information, compute the current magnetic declination and GM angle:

grid declination	3° W	
magnetic declination	4° E	
annual magnetic change		20' Easterly
original map date	1953	
current year	1988	

a. Magnetic declination:

ANS.

b. GM Angle:

ANS.

REQUIREMENT 1 SOLUTION

Section 1

1. 6° E

2. 211°

3. a. 205°

b. 260°

4. Four streams. If you fail to convert to a grid azimuth you will cross one stream.

5. a. 308 degrees
b. 35 degrees

REQUIREMENT 1 SOLUTION

Section 2

1. 4° E

2. 30°

3. a. 155°

b. 23°

4. Two times you will cross the trail. Must convert magnetic azimuth to grid.

5. 14 degrees. Grid back azimuth.

Section 3

1. 4° E

2. 269°

3. a. 14°

b. 345°

4. Single railroad track (must convert to grid azimuth)

5. a. 131 degrees
   b. 311 degrees

6. a. 16° E
   b. 19° E

END OF SOLUTION

APPENDIX B

REQUIREMENT 2

Map: Virginia, 1:50,000, Sheet 5561 III, Series V734, Edition 6-DMA

Section 1

1. What is the GM angle in the following diagram?

ANS.

2. What is the grid azimuth in the following diagram?

ANS.

3. Draw the diagram and solve the following:

a. magnetic declination 4 ° W
grid declination 3° E
magnetic azimuth 113°
grid azimuth ?

ANS.

b. grid declination 2° E
magnetic declination 7° E
magnetic azimuth 279°
grid back azimuth ?

ANS.

4. Starting at Woodbine School in GS 8782, moving on a magnetic azimuth of 232° 30', how many intermittent streams are indicated on your map between your starting point and Route 646?

ANS.

5. What is the magnetic azimuth from:

a. the road intersection in GS 8575 to Combat Village in GS 8674?

ANS.

b. the water tower in GS 9771 to the church in GS 9572?

ANS.

NOTE: The solutions for Section 1 are on the Solution Sheet. Check these to determine the accuracy of your work. Make necessary corrections. Proceed to Section 2.

Section 2

1. What is the GM angle in the following diagram?

ANS.

2. What is the grid back azimuth in the following diagram?

ANS.

3. Draw the diagrams and solve the following:

a. GM angle 6° W

grid azimuth 136°
magnetic azimuth ?

ANS.

b. grid declination 4° W
magnetic declination 1° W
magnetic azimuth 358°
grid back azimuth ?

ANS.

4. From the bench mark in GS 8781 you can see an enemy tank on a magnetic azimuth of 194° 30'. On what grid azimuth would the enemy tank see you?

ANS.

NOTE: The solutions for Section 2 are on the Solution Sheet. Check these to determine the accuracy of your work. Make necessary corrections. Proceed to Section 3.

Section 3

1. What is the GM angle in the following diagram?

ANS.

2. What is the grid back azimuth in the following diagram?

ANS.

3. Draw the diagrams and solve the following:

a. GM angle 5° E
grid azimuth 27°
magnetic back azimuth ?

ANS.

b. grid declination 5° E
magnetic declination 3° W
magnetic azimuth 163°
grid back azimuth ?

ANS.

4. Starting at the Hill in GS 8364, moving on a magnetic azimuth of 336° 30', what is the first manmade object you would come to on this azimuth?

ANS.

5. Solve the following:

a. What is the magnetic azimuth from the school in GS 8391 to the center of Old Dominion Speedway?

ANS.

b. What is the magnetic back azimuth?

ANS.

6. Given the following information, determine the GM angle in the diagram below:

annual magnetic change	15' Easterly
original map date	1963
current year	1991

ANS.

REQUIREMENT 2 SOLUTION

Section 1

1. 20° W

2. 137°

3. a. 106

b. 104°

4. Two streams

5. a. 119° 30'
b. 296°

Section 2

1. 6° W
2. 35°

3. a. 142°

b. 181°

4. 7°

Section 3

1. 7° E

2. 7°

3. a. 202°

b. 335°

4. Unimproved road

5. a. 148°
b. 328°

6. 1° E

END OF SOLUTION

APPENDIX C

REQUIREMENT 3

Map: Margarita Peak, California, 1:50,000, Sheet 2550 IV, Series V795, Edition 8-NIMA

Section 1

1. What is the GM angle in the following diagram?

ANS.

2. What is the grid azimuth in the following diagram?

ANS.

3. Draw the diagram and solve the following:

a.	magnetic declination	4° E
	grid declination	9° E
	magnetic azimuth	254°
	grid azimuth	?

ANS.

b.	grid declination	5° E
	magnetic declination	3° W
	magnetic azimuth	122°

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grid back azimuth ?

ANS.

4. Starting at the horizontal control station in GS 5490, moving on a magnetic azimuth of 101 degrees, how many streams are indicated on your map between your starting point and Piedra de Lumbre Canyon Road?

ANS.

5. What is the magnetic azimuth from:

a. the hospital helopad in GS 6988 to the reservoir in GS 6586?

ANS.

b. BM 139.3 in GS 7101 to BM 189.9 in GS 7402?

ANS.

NOTE: The solutions for Section 1 are on the Solution Sheet. Check these to determine the accuracy of your work. Make necessary corrections. Proceed to Section 2.

Section 2

1. What is the GM angle in the following diagram?

ANS.

2. What is the grid back azimuth in the following diagram?

ANS.

3. Draw the diagrams and solve the following:

a.

GM angle	9° E
grid azimuth	112°
magnetic azimuth	?

ANS.

b.

grid declination	5° W
magnetic declination	2° W
magnetic azimuth	198°
grid back azimuth	?

ANS.

4. Starting from the bend in the power lines in GS 6085 you will move on a magnetic azimuth of 211°. How many unimproved roads will you cross before coming to an improved light duty road?

ANS.

5. From the observation tower in GS 7291, you can see an enemy tank on a magnetic azimuth of 80°. On what grid azimuth would the enemy tank see you?

ANS.

NOTE: The solutions for section 2 are on the Solution Sheet. Check these to determine the accuracy of your work. Make necessary corrections. Proceed to Section 3.

Section 3

1. What is the GM angle in the following diagram?

ANS.

2. What is the grid back azimuth in the following diagram?

ANS.

3. Draw the diagrams and solve the following:

a.

GM angle	7° W
grid azimuth	161°
magnetic back azimuth	?

ANS.

b.

grid declination	5° E
magnetic declination	2° E
magnetic azimuth	147°
grid back azimuth	?

ANS.

4. Starting at the southernmost road junction in GS 5503, and moving on a magnetic azimuth of 174 degrees, what is the first manmade object you will encounter?

ANS.

5. What is the magnetic azimuth from the water tank in GS 7484 to the church in GS 7185?

ANS.

REQUIREMENT 3 SOLUTION

Section 1

1. 8° W

2. 202°

3. a.

249°

b.

294°

4. 4 streams

5. a. 228 degrees
   b. 46 degrees

Section 2

1. 3° E

2. 113°

3. a.

103

b.

21°

4. 3 unimproved roads

5. 274° 30'

Section 3

1. 5° E

2. 262°

3. a.

348°

b.

324°

4. windmill

5. 277 degrees

'

APPENDIX D

REQUIREMENT 4

1. You are a communications officer assigned to a Marine Expeditionary Unit (MEU) afloat. You have been tasked with setting up a radio relay site in support of an operation ashore. Your relay site will provide communications between the MEU (which has already landed on a hostile shore) and friendly ground forces. The current distance between these two forces is approximately 300 miles and your relay site will be positioned approximately midway between them. The S-2 issues you the only maps he has of the area you are going into. After your initial map study you determine that from your insertion point you must travel on a grid azimuth of 120° for 1200m over relatively featureless terrain to get to the best position for your relay site. The maps issued to you were printed in 1962. The declination diagram from the map is provided below. You must board the insertion aircraft 3 hours from now. Assume the current year is 1991.

APPROXIMATE MEAN DECLINATION 1960 FOR THE CENTER OF SHEET. ANNUAL MAGNETIC CHANGE 7' WESTERLY.

Questions

1. What is the GM angle you will use relating to this map?

ANS.

2. What is the magnetic azimuth you would follow from your insertion point to the relay site?

ANS.

REQUIREMENT 4 SOLUTION

1. 12° W

To determine the current GM angle of the map:

a. Declination data as of 1960 with an annual change of 7' Westerly.

b. Determine # of years: 1991
-1960
31 years

c. Multiply # of years by annual change:
31 yrs x 7'/yr = 217'

d. Determine # of degrees of change:
217' ÷ 60'/degree = 3.61°
= 3.5° (round to nearest .5°)

e. Apply change to update GM angle:

Old GM>		Change		Current GM>
8.5° W	+	3.5° W	=	12° W

2. 132°

To determine the azimuth, use one of the following methods:

a. MA ± GM = GA
E +
W -

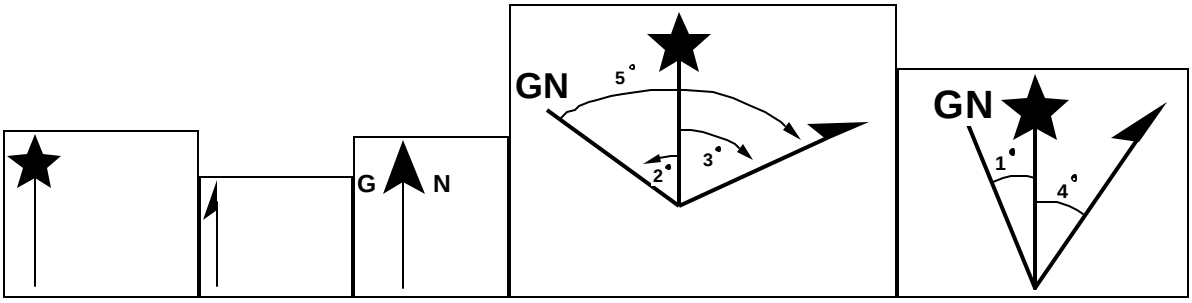
grid azimuth = 120°

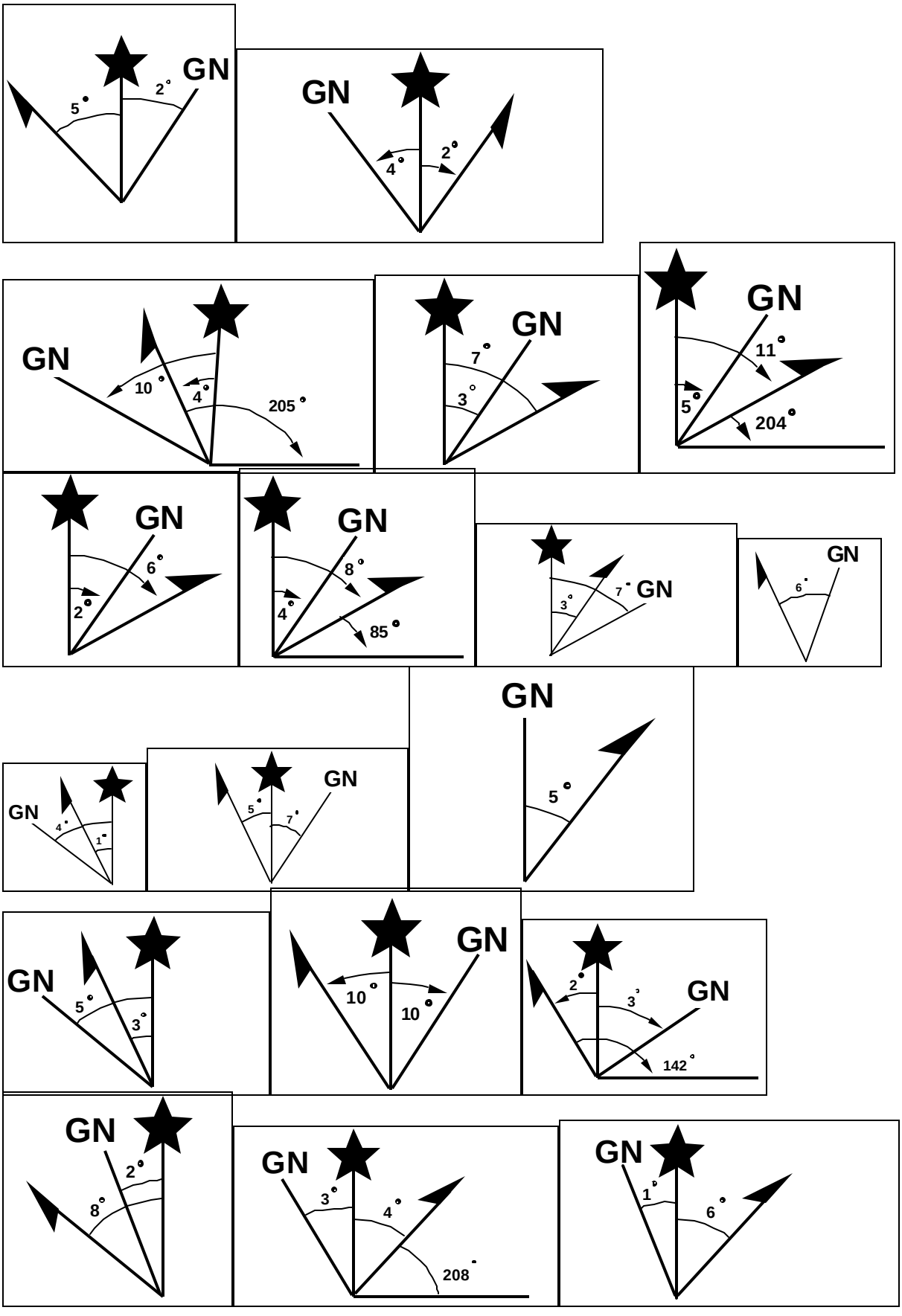
MA - 12° = 120°
MA - 12° + 12° = 120° + 12°
MA = 132°

b. LARS

You started with a GA so go to the grid declination line and move to the mag declination line. You moved Left so you Add the GM angle to the GA to determine the MA.

120° + 12° = 132°




GN
5°
2°
GN
4°
2°
GN
10°
4°
205°
GN
7°
3°
GN
11°
5°
204°
GN
6°
2°
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85°
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142°
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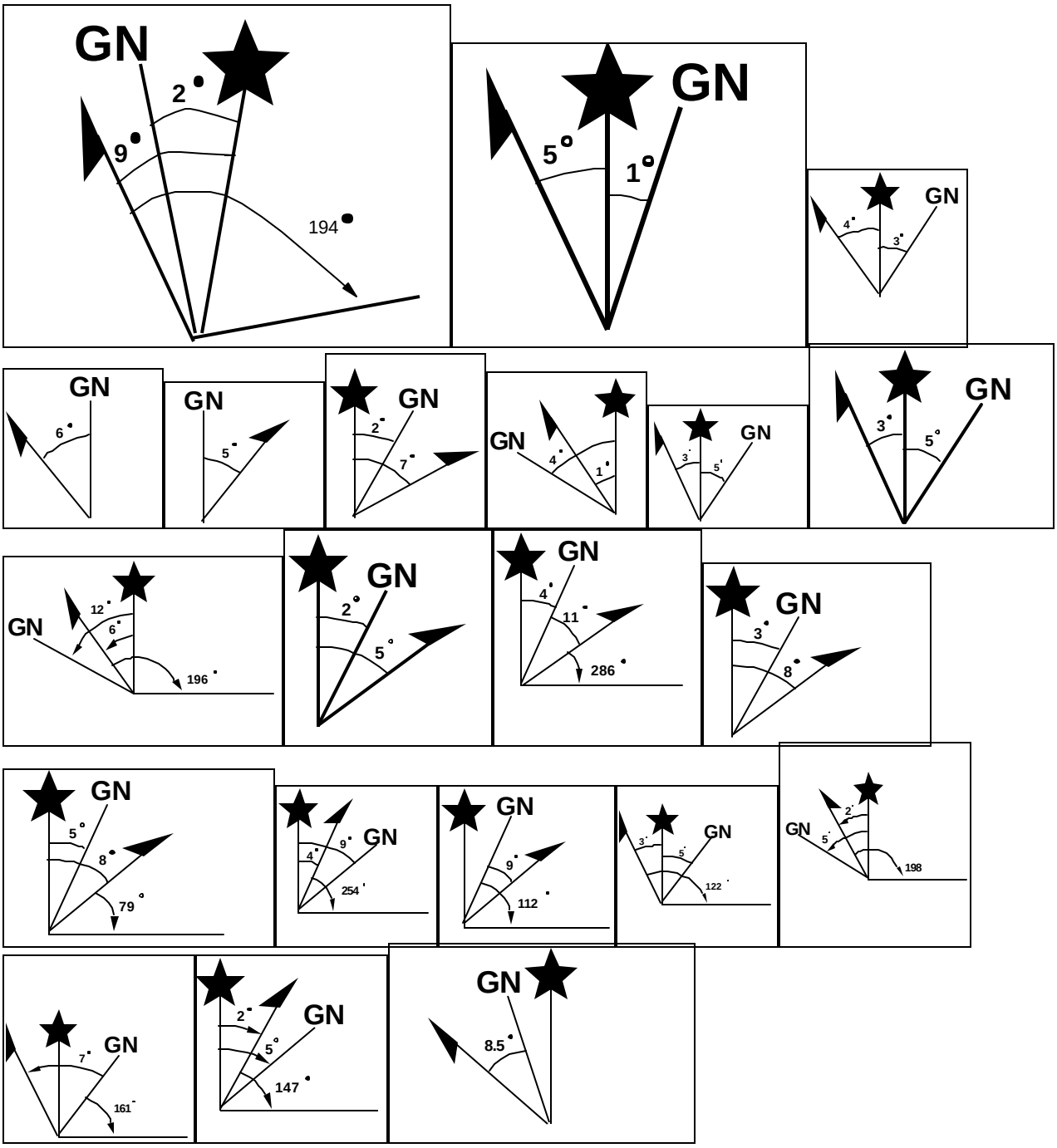
8°
2°
GN
3°
4°
208°
GN
1°
6°


GN
2
9
194
GN
5°
1°
GN
4
3
GN
6
GN
5
GN
2
7
GN
4
1
GN
3
5
GN
3
5°
GN
12
6
196
GN
2
5°
GN
4
11
286
GN
3
8
GN
5°
8
79°
GN
4
9
254
GN
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112
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122
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198
GN
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161
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2
5°
147
GN
8.5